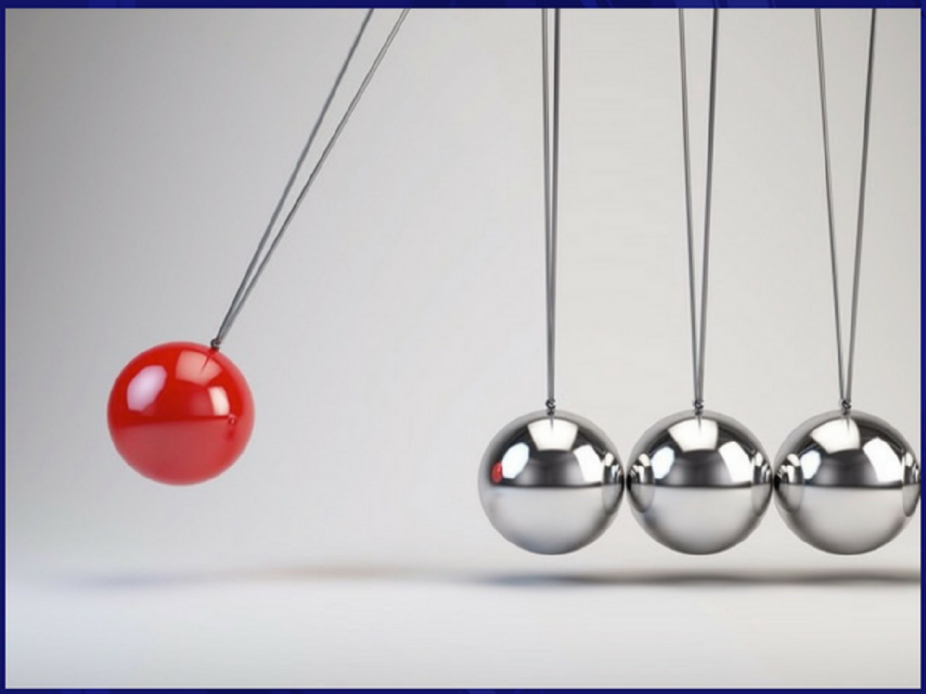
Physics of the Human Body

Lose Weight for Good



Pedro Hugo García Peláez

Physics of the Human Body

Lose Weight for Good

By Pedro Hugo García Peláez

Translated by Morwenna Fellows

Dedicated to my mother with all my love.

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PROLOGUE

The book is beginning to take its desired form; a few years ago an idea came to me about how to swim in order to better optimise the exercise, and that idea worked. Then, after a few years, I found some formulas that could be applied to how to keep the body at rest in the water, and I proved that they also worked. The first step strengthened the body in general and above all the abdomen, which was left without a drop of fat, the second step managed to relax the body.

I do not know if this will be the end of the book, although technically it already contains all of the material necessary for our objectives it must be given the necessary form, and I do not know if there will be another edition.

I am a physicist not a medic and I apply the laws of physics to the body, such as the human body in water. The method works and there is no need to brood over it, especially in the field of physics, which is an exact science.

Additionally, I am the author of a short novel which I have spent almost five years writing and finalising, for this reason I say that writing a book and giving it the appropriate form involves more work than one might initially think.

I have spent almost three years on this technical book and it is close to completion, not in terms of the content, which is complete, but rather in terms of the form that I want to give it.

The book is divided into two parts, static and kinematics.

Static can be defined as the body's rest. The way that Newton defines static is that if a body on which no force is acting is at rest it will remain at rest. We are going to use a more general definition and we are going to define static as when there is an excess body all the forces that act on this body are cancelled out and the body therefore remains at rest.

As I have already introduced, the book proposes two concepts that will serve our purposes; the rest of the human body in water and the movement of the human body in water.

To achieve our objectives we must use the formulas that help our aims, bearing in mind the characteristics of the human body.

I have two advantages when writing this book, that I know what I want to write and that being a technical book I do not have to invent a fictional ending.

There are some approximations that are fundamental and on which practically the whole idea of the book is based. In ‘Static of the human body in water’ we are going to consider the human body as a body formed of an infinity of rods of uniform density that are at equilibrium in the water.

In ‘Kinematics of the human body in water’ the only approximation is to compare the human body to a floating board; we are going to consider the swimmer to be like a board that goes up and down as it moves forward.

There is a problem with people who are not familiar with scientific subject matter as this is a scientific book and I have to describe as precisely as possible the motions and the circumstances in which the movement happens because undoubtedly there will be somebody who improves this book in the future. I must describe the process for the readers who are experts in

science so that all of the measurements and formulas are well outlined. At the same time I must try to make sure that somebody not specialised in the sciences can use the book to improve their health and physical well-being.

The book is going to be divided into two sections, Static and Kinematics, just like in electromagnetism. Static electricity is the first part of the study of electromagnetism, electrodynamics also produce another phenomenon, magnetism, these are studied combined as what we call electromagnetism.

In this book the chapter ‘Static of the human body in water’ addresses the body’s rest as regeneration and self-recovery, and ‘Kinematics of the human body in water’ deals with pure hard exercise that will make us suffer, although in a very moderate way.

Returning to the consideration of issues that are not within the grasp of those readers not well versed in scientific topics, I will put a note explaining about its complexity and how it should be read cursorily. However, these aspects are necessary for those readers who are scientists, who in the future can perhaps improve these ideas from some simple concepts that can afford them a clear visualisation of the idea.

Without letting myself be carried away by euphoria, the book is an innovative idea and as has always happened in the history of science, in the future there will be somebody that can improve it.

I hope that you enjoy this book as much as I have after having developed it over six years, and that you see that it works in terms of enhancing your health and physical well-being.

What works works and there is no need to dwell on where a physics formula comes from, as physics has its own laws, much like poetry does.

The exercises should be done in water and you will need two things: For the static exercises a bath in which your whole body fits stretched out, and a swimming pool of a minimum of 20 metres for the swimming exercises. Without these requirements it is impossible to carry out the exercises.

Why in the water? Primarily because the density, that has quite an impact on the physics framework that I have designed, is trivial in the air and is therefore useless for our purposes. Additionally, the density of the mattress where we rest is infinitely greater than that of water, and a force, called normal', acts on our body and is concentrated on the parts that are more in contact with the mattress, not on our entire body. Consequently, the water becomes an

intermediate element that adapts perfectly for our purposes.

CHAPTER 1

STATIC OF THE HUMAN BODY IN WATER

In physics statics and kinematics were some of the first problems that the early physicists faced.

The first cathedrals had to support a great weight but they had to have a static character, a harmony that united its grandeur with it solidity.

The physical laws of the human body, as much when moving as when remaining stationary in the water, differ slightly, or better said rather a lot, from how they behave on solid ground and in the atmosphere.

On firm ground, because a force, called normal, acts in total opposition to weight, we all notice a painful behind when we are sat in a chair for a long time.

In water, because it has a lower density, we do not notice this normal force. What we notice is an upwards force equal to the volume of the dislodged weight, but as the density is less and it is a material that adjusts to the volume, we say elastic, we do not feel this discomfort of the normal force.

A mattress that we use to rest has a very high density compared to water, and the normal force also acts not on our whole body but rather on the parts that are supported on the mattress itself.

We can consider water as an ideal mattress.

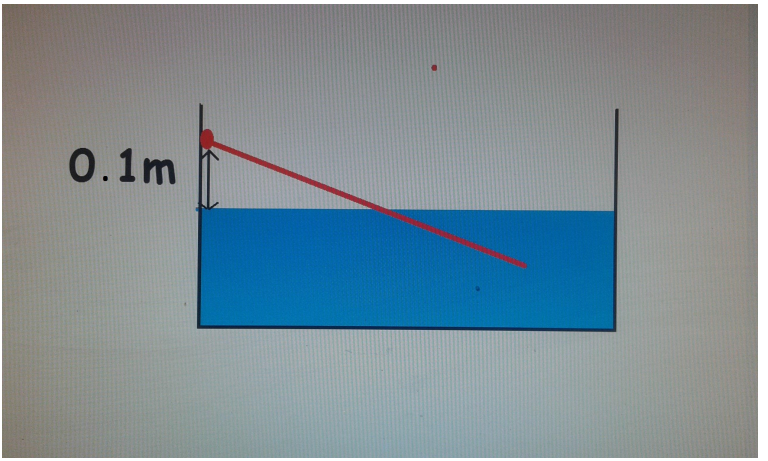
Ultimately, if water is so important for living beings, how we relate with it is also important. In other words how the human body behaves in water has its own rules of physics and these are what I am going to describe in this book.

The definition of static in physics is that of a body where all the forces are cancelled out and it is at rest. This includes rotational rest, a spinning top can stay in the same place but be rotating and it would therefore not be at rest.

It is quite interesting that the way we are going to see our physical body interact with the water in a static and kinematic way has some expressions that can be simplified a lot, our human body resembling a board, or a board formed of an infinity of rods.

We will begin with the most simple problem, which is comparing the human body to a board

formed of an infinity of rods. I am going to illustrate this with a drawing comparing a rod secured at one end but which at the same time can oscillate, and what its form at rest in a container full of water would be.

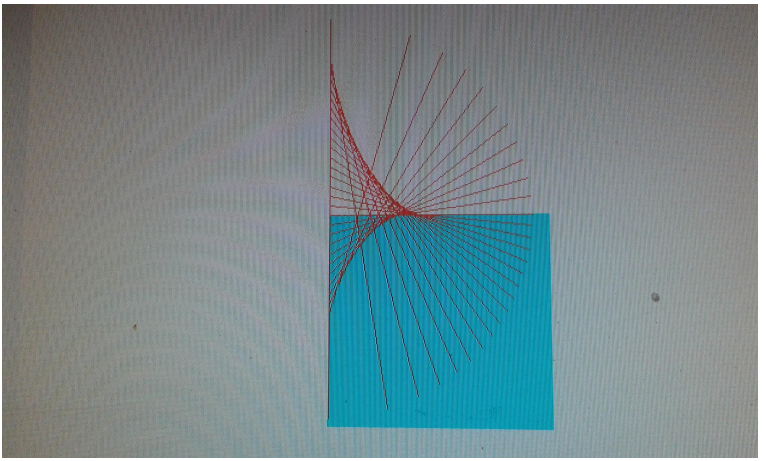


Broadly speaking this would be the position of equilibrium in the water of a rod of something

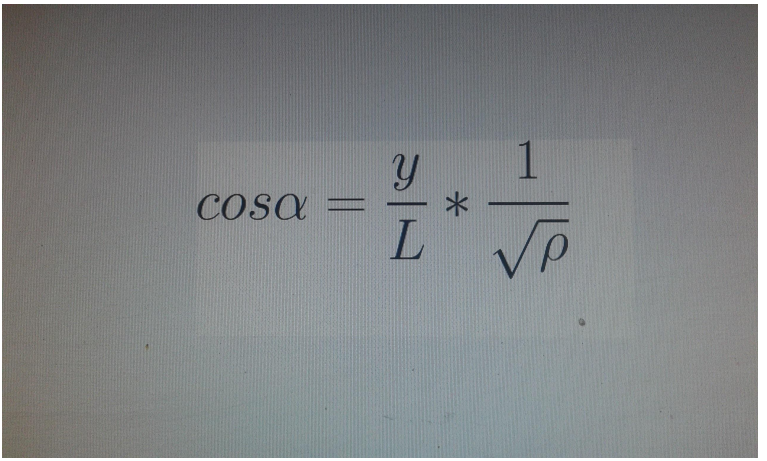
less than one metre fixed at 0.1 metres above the level of the water.

To compare the human body to a board formed of an infinity of rods is totally valid, but for this we need to know the approximate density of our body, which is approximately the same as that of water.

A rod attached at one end has these different points of equilibrium when it has one part submerged in the water, these equilibriums depend on where it is attached.



The formula that governs the equilibrium of an individual rod is determined by the formula:



$$cos\alpha = \frac{y}{L} * \frac{1}{\sqrt{\rho}}$$

-y- Is the distance between the point of attachment and the surface of the water.

-L- Is the length of our body.

-p: Is the relative density of the water in relation to the submerged body in the form of a rod, which is 0.95 in the International System and in our case.

-cosine of alpha is the angle that our body makes with the vertical.

Additionally, if an individual rod, made of our body, is governed by that equilibrium, then the entire body, which we consider to be formed of a multitude of identical rods, will have the same position of equilibrium.

It is in our interest to know the angle that our body should form with the vertical to be at absolute rest when it is partially submerged in the water.

Therefore, for a 1.7m long body situated at 0.1m from the surface of the water, and of a relative density of 0.95 in relation to the water:

Cosine of alpha = 0.27

A cosine of alpha equal to 0.27 equates in sexagesimal degrees to an angle of approximately 74º.

To find out the sexagesimal degrees we need to find out the arccosine of the discovered quantity.

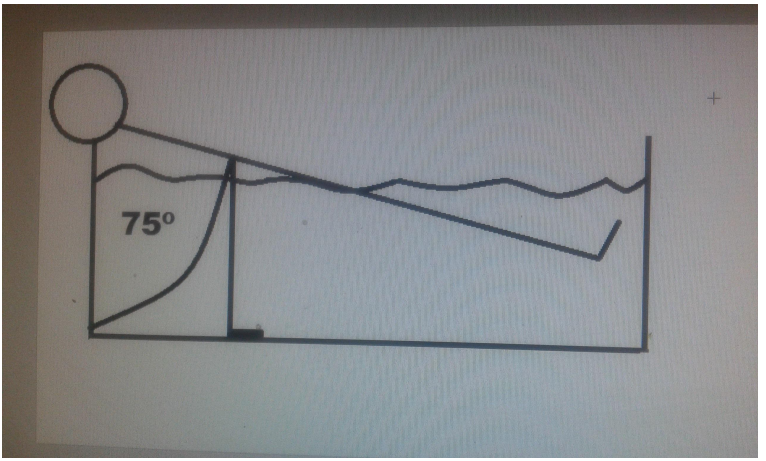
For example, cosine of alpha = 0.27, arccosine of 0.27 =74º

Therefore the body ought to be totally straight with the head slightly out of the water and the feet just submerged in the water.

This should be the position of your body when at rest in the water. The arms will help to fix your position, and consequently your body will more

closely resemble a board formed of a multitude of rods.

An illustration is included:



This posture is extremely relaxing for the body as it is in total equilibrium with the liquid. To put it one way, it is the closest thing to weightlessness and achieves total rest.

It must be said that it is not strictly speaking an exercise and only helps to relax the body momentarily. Nonetheless, it serves as an

introduction to see how physical laws govern our bodies in the water.

I personally do it in a hot bath for five minutes, and it relaxes me to then enter a sauna. Whichever way, it helps to relax momentarily if that is what we want.

Bear in mind that the exercise must be done with the legs together.

It could be done in a small bath with the arms and legs individually, but in my experience it is not worth while as it is when the whole body is at equilibrium that greater efficiency is achieved.

In terms of the kinematics, to swim in our own flotation period we need a twenty metre long swimming pool, although it can also be done in the sea.

CHAPTER 2

KINEMATICS OF THE HUMAN BODY IN WATER

INTRODUCTION

Writing this book I have realised that it is not necessary to introduce complicated concepts, such as differential equations, to justify where the formula for the flotation period of a body with squared symmetry, or the equation for a simple harmonic motion, as that would be material for a purely physics book.

From experience, it is probable that some of my readers understand what a derivative is, but if on top of that you add the resolution of a differential equation you will bore them, and I

aim to reach the general public, from a housewife to a professional of any kind.

Consequently, I have written a book that, although it is purely scientific and based on physics, can be read by anyone and is written in straightforward and clear language.

The most difficult thing that you will have to resolve is a square root, in other words things such as: the root of nine is equal to three because three times three is nine.

$$\sqrt{9} = 3$$

which with the help of a calculator doesn’t pose any problem.

*Note: This unit is purely introductory. It deals with the physical phenomenon's that occur when a body enters into resonance upon oscillating in its own period of natural oscillation. If you do not have much knowledge about physics it should be skimmed over without paying too much attention to the technical details.

UNIT 1: Physics principles of the period, simple harmonic motion, and resonance.

I have a motto:

"That which cannot be measured is not much use".

Obviously, intangible things such as love exist, but when somebody says to you "I love you a lot" you do not know if they are saying it to you in earnest or if they are lying, numbers don't lie. This book aims to give you the necessary tools to

discover the times in which you should swim, depending on the characteristics of your own body.

In reality what I am going to tell you is intimately linked to the force of gravity. Gravity is a force from a distance, which means that the earth attracts an aeroplane even though there is seemingly nothing that unites them. I am not going to go into considerations about if there is a space-time grid , or some imaginary strings that connect everything, like in string theory.

In fact everything is going to be very simple, the most complicated thing that you are going to have to do are square roots. The square roots are another number that when elevated to squared gives the number that was originally inside the root, that is to say: the root of nine is equal to three because three times three equals nine.

$$\sqrt{9} = 3 \text{ because } 3 * 3 = 9$$

You should also know the International System of Units.

I use the International System (SI) as it is the most used in physics.

Its principle units are seconds for time kilograms for mass, and metres for lengths.

What I am going to write in this book is not a scientific discovery, it is simply an application of classical mechanics to the exercise of swimming.

Classical mechanics is the mechanics of Newton and is the mechanics of big bodies, we are not going to go into relativistic considerations or any type of quantum mechanics.

I have already introduced the fact that what I am going to write in this book is intimately linked to the force of gravity. Now we are going to go a step further and I am going to explain what a simple harmonic motion is, (hereafter SHM).

An SHM is simply the movement of a swing. If we omit the rubbing of the chains against the point where they are attached the swing would continue swinging eternally at the same tempo and with the same range.

Why would the swing continue to swing in exactly the same way forever? The answer is in the force of gravity.

In certain circumstances the force of gravity produces a free force, which will result in benefits if we know how to make the most of it.

I am obviously not saying that the force of gravity produces a free force redundantly, rather that in particular circumstances, such as creating a tunnel that would cross Earth, it would produce an SMH that would produce free energy.

This free energy could be used to propel rockets, with a considerable saving of energy. Obviously, the cost of constructing this tunnel that would pass through the center of the Earth

makes it unviable, aside from the great engineering problems that it would entail.

Ok, we now know that in some circumstances the force of gravity produces a free force and that it also produces an SMH.

I am going to give the example of a pendulum. A pendulum swings more slowly the greater the length of its cord. We are going to think of the arm as a pendulum, obviously a longer arm should swing more slowly if we compare it with a pendulum. This is important, we should not move it more slowly based on rough estimates. There is a physics formula that measures the time in which you should move your arm, to two decimal places, if you consider it as a pendulum.

The formula for the time period of a simple pendulum is: 2 times π, times the square root of the length of the chord divided by the square root of the acceleration due to gravity, we consider the chord to have a negligible mass.

When we talk about time period and frequency we are talking about the same thing, they both mean a time in which two identical events are repeated.

In fact the frequency is the of the time period, I prefer to use the cycle as for me it is a simpler way of describing time than frequency. Frequency is used more in waves as some physicists find this concept easier to help visualize some properties of waves, but I repeat that the time period and frequency are the same thing, only that one is the inverse of the other and they both measure the time in which two events are repeated.

In fact the frequency of television waves could be measured using the time period. That is to say that a 50 hertz wave is simply a wave with a time period of two hundredths of a second, that is that it repeats its own conditions every 0.02 seconds.

50 hertz = = 0.02 seconds

Just physicists obsessions, and in reality we are very obsessive.

Furthermore, when we talk about the natural flotation period of a body we talk about the intrinsic period of oscillation of each body. When we push a body down in the water and we avoid friction, which in the water is very small, the body goes up and down following a simple harmonic movement in a time that is characteristic to each body, and is intimately linked to its form.

We can measure the natural period of oscillation of its swing, although friction exists. I repeat again that in the water this friction force is very small.

We will name the extra force that we must do to maintain the natural period of its own swing:

Fo

Although this force is constant, applied to a strategic place the movement obtains a frequency close to that of the oscillator, and that is when the resonance effect is produced.

Despite the fact that this force is constant, if it is applied to the body in certain moments it makes it very efficient at causing a greater range of movement over the body on which it is acting.

If the force is applied in misalignment with the swing its efficiency will not be very great, but if it is applied to a swing in the moments of its greatest extent it will be very efficient and will

achieve a considerable increase in the extent of the swing.

Why swim in your own natural flotation period? Basically because you don’t come into an inconsistency with the force of gravity, and you are therefore making the most of your best effort.

The time in which the body sinks a little in the water returns to the surface and then sinks again to the same position is what we call time period, and it is measured in seconds. The time period is the time in which a movement is repeated in exactly the same way in segments.

In the movement of a pendulum is the time in which the particle repeats the same conditions of speed, acceleration, and position. Said more simply, if we move a pendulum that is suspended from the roof and we let go the timehe swing

would be the time it takes to go and return to the same position from which we let it go.

We now understand that a floating body has its own natural oscillation period.

We are also going to go into the last important concept that we should know, and that is resonance. Up to now we have seen systems that oscillate freely, and others that are subject to an occasional force.

A swinging pendulum is a body that swings freely.

A body floating up and down is a body that is subject to an occasional force, in this case it is produced by our own interior muscles. If we make this force happen in the adequate moments we will achieve that the range of movement increases considerably.

Now I am going to give an example of a swinging body subject to a moving force. The swinging body is the glass and the moving force is the note that the soprano emits, the soprano manages to break the glass using her voice.

The mechanism for breaking the glass is the following: the soprano emits a continuous note and the note has a fixed time period that makes the air vibrate continuously in the same way and in the same time, if the glass begins to vibrate before or after that same period it produces a force called resonance which causes the glass to break.

The Talmud is a Hebrew book about religion and laws.

It is interesting because it was written 4000 years ago and a precept to the book said:

If a rooster puts its head in an empty glass container and crows there until the container breaks then the whole cost will be paid.

The Talmud (Baba Kamma, Chapter 2)

For this reason it is called resonance, and it appears that it was known about thousands of years ago.

As we have seen, the mechanism is the same as when a soprano breaks a glass with a sustained note.

In his books ‘Acoustics’, Alexander Woods states (Blackie and Son, London 1940): It seems difficult to believe that said legislation was designed to cover a case that would never arise.

A French physicist, who as well as raising cockerels, described the precept as unnecessary as he never saw a cockerel put its head in a vessel and break it with its crowing.

In a nutshell we can see that resonance was known about from the beginning of civilization, where the legislators categorized it in a slightly strange way, in terms of a phenomenon that almost never occurs, unless in those times it was a problem big enough to typify.

The army bears in mind the same considerations, because when a battalion goes over a bridge they fall out of step so that the force of the troops legs in unison do not resonate with the bridge's structure and make it fall.

These last phenomena are important, as bodies subject to driving forces that resonate.

Lord Kelvin, famous for his contributions to thermodynamics and creator of the Kelvin scale, said:

The vibration of interconnected particles constitutes a particularly interesting and important problem…it must have many uses.

Lord Kelvin, Baltimore Lectures (1884)

Now I am going to begin with the system that concerns us, which is the body as a free system that is driven by a periodic force.

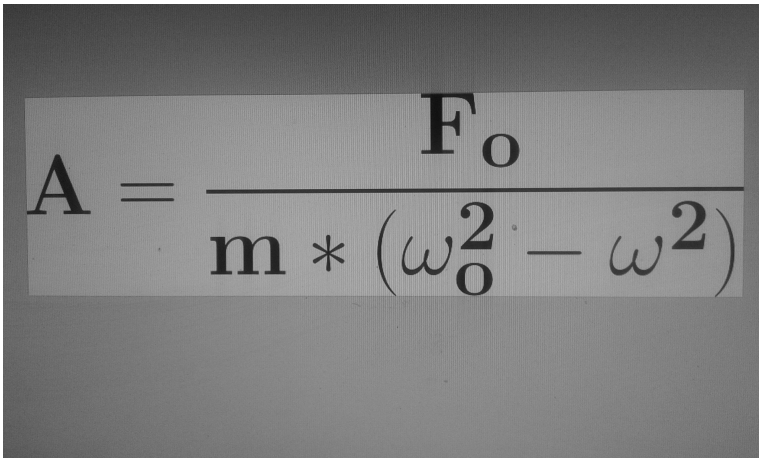
The body is the free system and the driving force is our own muscles.

I am going to give the formula for the range of movement for a simple system, such as the body floating in water, which oscillates due to both a

constant and periodic force with a small amount of cushioning that is provided by our own internal muscles.

When the force prevails, that is to say when the transitory effects have passed and we achieve the oscillation of our body close to its natural flotation frequency, the range of movement tends to increase infinitely.

This is the effect of resonance, the formula of which is:



$$A = \frac{F_o}{m * (\omega_o^2 - \omega^2)}$$

(A) Is the amplitude of the oscillation.

In the event that the force of an earthquake moves the earth with the frequency (w) and that a house vibrates with an almost equal frequency, the range of movement would stretch to infinity as the denominator becomes close to zero.

Wo

Would be the frequency with which the house vibrates.

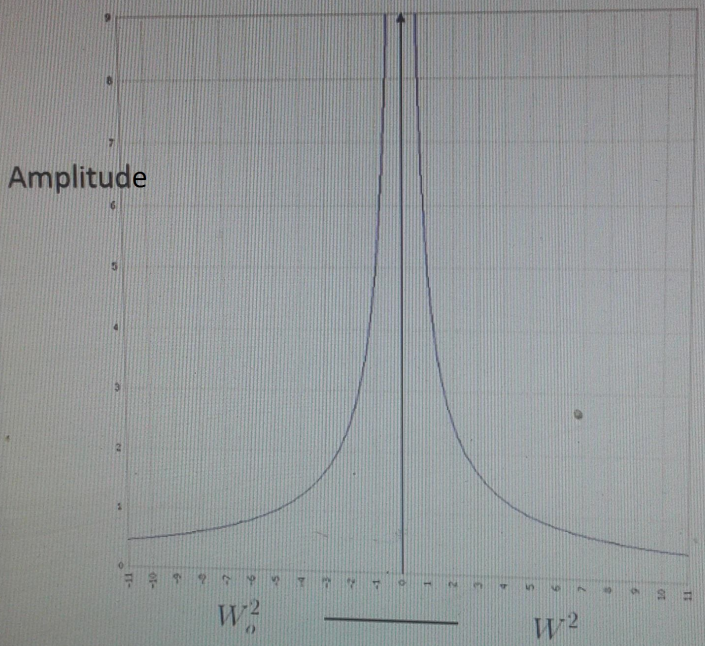
w

Would be the frequency with which the earthquake makes the earth vibrate.

Let’s imagine a graph where the natural oscillation frequency of the house is close to the frequency of the periodic force of the earthquake moving the earth, we see that the amplitude of movement extends to infinite.

We can see the graph in the following illustration.

The amplitude tends to infinity when $W_o^2 = W^2$



This phenomenon is called resonance.

Wo

Is what we call the natural oscillation frequency of a body, if the natural frequency of oscillation of the house coincides with the driving force of the earthquake it may be knocked down, similarly the body has a natural oscillation frequency when we swim.

As we will see in due course, the body has a natural oscillation period, and if we move it with our own periodic force in a similar time period to our own natural oscillation period when floating, we will procure that upon floating we enter into resonance and the range of movement increases considerably.

The range of movement will not reach infinity due to forces such as the weight of the swimmer, friction with the water and its push, but it will increase, and this will produce remarkable benefits when doing the exercise.

Returning to the topic of the resonance of the body when floating, it is important that the body goes into resonance, because aside from increasing the range of the movement we don't enter into inconsistency with the force of gravity.

We do not need to use a great force, rather we are making the most of the fact that we can know the time in which we should go up and down when swimming to get the most out of it and do that exercise in harmony with the force of gravity.

Resonance is produced between a body that oscillates freely, but is subject to a periodic force

that is applied in strategic moments, making the range of the movement increase considerably.

Finally, I repeat that in the equation of the period of a simple pendulum we see that the only variable is the length of the chord, the rest are constants. If there was not this variable all pendulums would move in the same time period and all arms and legs would have the same natural oscillation period. It will therefore be this variable that determines how a person should move their arm imitating the movement of a pendulum, in the time that corresponds to it.

We will then see that, surprisingly, the natural flotation period of a body with squared symmetry and that of a simple pendulum have the same formula.

We see that the key word is ‘resonance’ and I am going to give you the necessary tools for you to

achieve that your body goes into resonance with the water when you swim.

*Note: This unit is essential to know the way and time that we should swim in, although it may be difficult to understand, it should be studied completely and you should try to understand it all.

UNIT 2: To achieve that the oscillation of the abdomen goes into resonance with its own natural flotation period with a degree of freedom

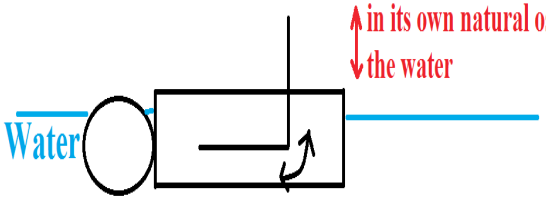
We will now see how to make your abdomen go into resonance with its own natural flotation period in the time that we find for each person.

The formula to find out the time is specified in unit 3 and, as we will see, it is a very small amount of time and depends on the width of a person's flank, for a normal person it ranges from 0.6 to 1 second.

To achieve such a short time we must use the arms as pendulums that transmit the energy to the abdomen, making it vibrate in this short time.

The exercise is illustrated in the following figure:

By moving your arms quickly you manage to make your abdomen vibrate in its own natural oscillation period in the water



Swinging movement of the arm makes the abdomen oscillate in its resonance frequency.

*Note: This unit is essential to know the way and time that we should swim in, although it may be difficult to understand, it should be studied completely and you should try to understand it all.

UNIT 3: Swimming in our own period of natural oscillation frequency in the water.

We have seen the range increases considerably when it enters into resonance, a small earthquake can bring a house down if the periodic force of the earthquake goes into resonance with the house's natural frequency of oscillation.

This is obviously more simple in a system where the mechanism oscillates freely, as the pendulum swings freely and would only stop if there is enough friction to lessen the movement. However considerations of resonance come into play when a constant but periodic force is applied.

Another simple system would be a board that we lightly sink into the water and it begins to oscillate up and down, this turns back into an SMH, as in the case of a pendulum, the board now oscillates up and down in the water in its own time and continuously, as a pendulum does.

Just like the movement of a pier going up and down.

Several years ago an idea came to me, as if fallen from heaven, it was September. In January I had a mechanics exam and I spent the day solving

problems. Such was the skill that I had for resolving problems that I almost divined new variables. I mastered most of the problems for the degree exam, I put in a lot of effort and mastered practically all of the problems that I had to face, and the truth is that I went to bed exhausted.

One morning an idea came to me when I woke up, that, despite being simple, could manage to improve the calculations used for how a person should swim.

I don’t know if the idea came to me by divine inspiration or because of the tremendous work that I was doing resolving the problems.

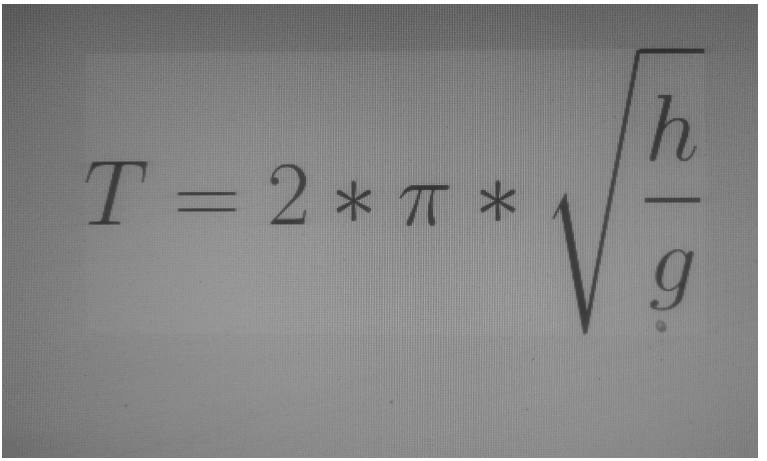
The idea was to make the human body resemble a board, when we float in the water without moving, the body is quite similar to a board.

It was November and the following day, after having measured my natural flotation frequency and exerting a force with my own muscles to swim twenty five metres in that time, I went to a spa in Madrid. I saw immediately that the fat accumulated in my abdomen disappeared almost instantly. It was like putting the abdomen in a centrifuge machine, if I may say so.

If we lightly sink a board in the water it will rise up and down in its own time. Moreover, it does not matter if we sink it a lot or a little, it will always do it in the same time. Obviously, if we sink it more it will do the trajectory of going up and down more quickly as it must cover more space in the same time.

This is an important characteristic, the range, that is to say the trajectory covered, is independent of its characteristic time period. Additionally, in the water there is less friction, which is why the invention works. A board has

the same natural oscillation period as a boat with square sides, in other words a tanker.



The formula is: 2 by π, by the square root of the weighted mean of your side (h) divided by the square root of the acceleration of gravity. That is to say 9.81 meters per second squared, which is exactly the same as that of a simple pendulum, only that now the length of the chord is the width of your own side, if we consider the body as a floating board.

The only variable is the width of the person's side (h).

2* π results from the SMH that a floating body that is linked to the circular movement has, we all remember that the formula of the longitude of a circumference is:

$$L= 2* \pi*r$$

(g) Is the acceleration of gravity on Earth and comes after simplifying the weight of the swimmer and the pushing force of the dislodged water, in other words, Archimedes law.

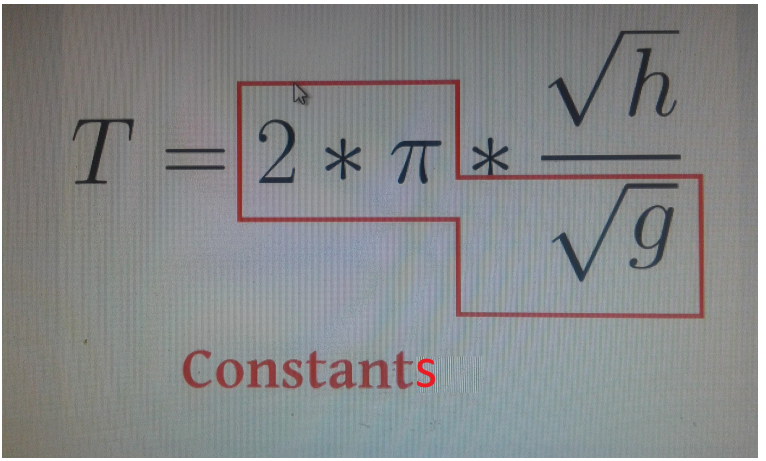
The width is a variable because you have to bear in mind the density of the liquid, which is its mass divided by its volume, which in the case of water

is close to 1 kilogram divided by cubic meter, and very similar to the density of a person.

That is what allows us to float in water.

From there comes the variable of the width of the sides (h), if that variable did not exist, all men, boats etc. would have the same natural flotation period.

We can see that in the formula for the natural oscillation of a board in the water there is only one variable, we can therefore simplify this and it becomes:



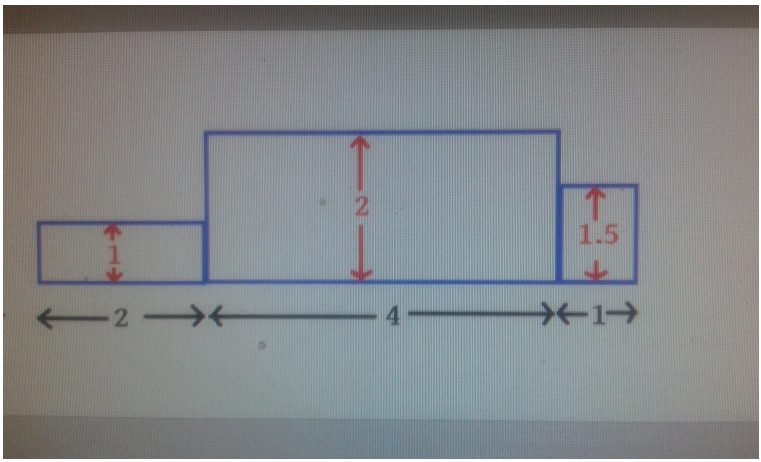
T= 2* √h

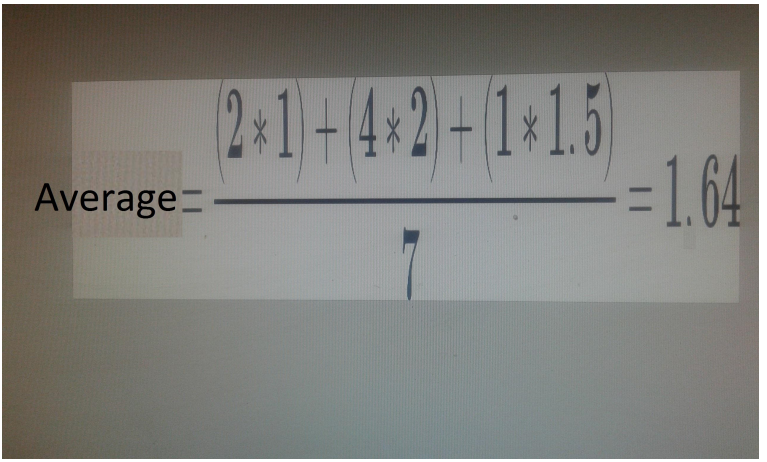
Therefore we should multiply the square root of the weighted mean of the width of our side by 2 to find out our natural flotation period in seconds.

A weighted mean is a mean estimated from different measurements of the same body, for example, in our chest there is a greater side

width than in our ankles, and the thighs have a greater width that the ankles, but less than the chest.

A weighted mean of the width of the following figure would be:





On the one hand, we are taking into account that:

(g) the acceleration of gravity is constant in all parts of the planet, unless you do the exercise in a swimming pool or on a peak in the Himalayas.

On the other hand, (g) is characteristic of planet Earth, if you did it in a swimming pool on the moon then it would have another (g) as the force of gravity is less on the moon.

What do we achieve with this? First and foremost we achieve that our body goes into resonance with its own natural flotation period because of the force of our own internal muscles, producing a periodic force that coincides with our natural flotation period, which is no small feat.

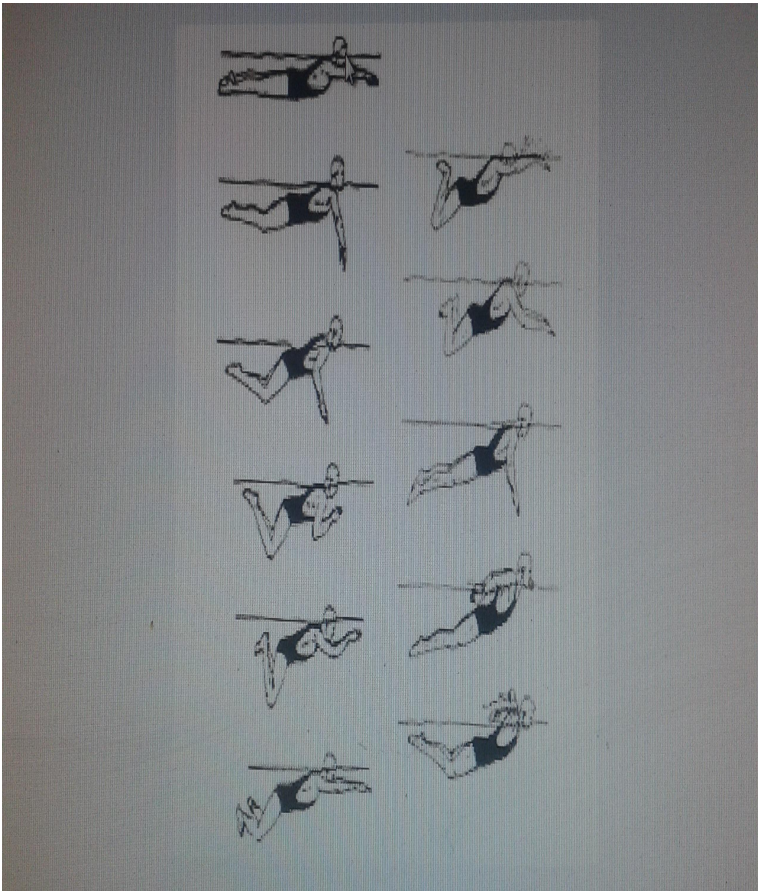
We therefore see that an obese person must swim more slowly, since the variable is in the numerator. By being bigger than a slim person the time period is greater and therefore they must do the entire movement in a longer time, and consequently more slowly.

The period is the time in which the body should be in the same position after having gone down and up again in the water.

If you calculate a weighted average of the side of a human it is 14cm, (wider at the thighs, narrower at the ankles and even wider at the stomach).

Measuring this variable of your body we can now measure the time in which we should do a complete stroke, in the case of a side with an average width of 0.14 metres the period is 0.75 seconds.

That is the time in which we have to do a complete stroke (from when we start to do the stroke, submerge, and come up again to the same position).



In this way we achieve that the force that we make to produce this movement goes into resonance with the movement that operates on our body when floating.

To get the abdomen to oscillate in such a small time we should do the stroke moving our arms and legs very quickly so that the momentum makes the abdomen vibrate in such a small amount of time.

It is interesting that the time is close to a second, which is the unit of time of the International System of Units.

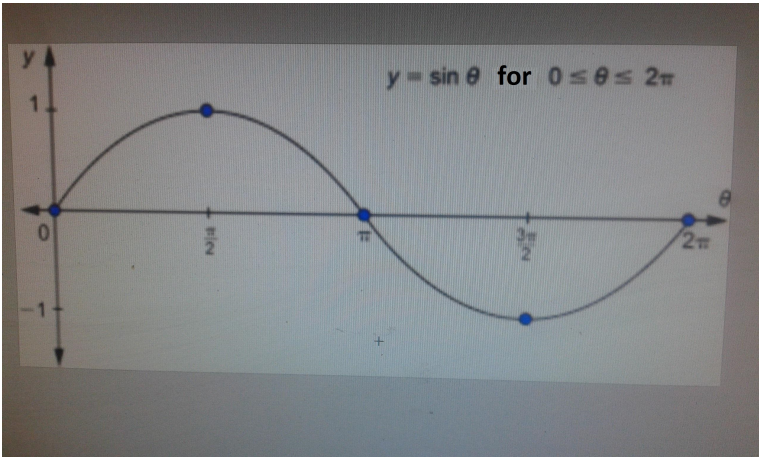
The flotation period of a human varies between 0.6 and 1 second, depending on whether the person is very thin or quite obese.

Although it is better to do it in a big swimming pool or in the sea swimming for ½ a minute or advancing about twenty metres. Resting and going back to swimming, for ten minutes in total, two or three times a week. It can also be done in a small swimming pool without advancing much, although the results are much less impressive.

No matter what, even if you do the stroke without advancing much, you should do the submerging and rising to the surface movement in the time worked out.

That is to say, that this can be done in a small swimming pool, but I repeat that the results are much less impressive.

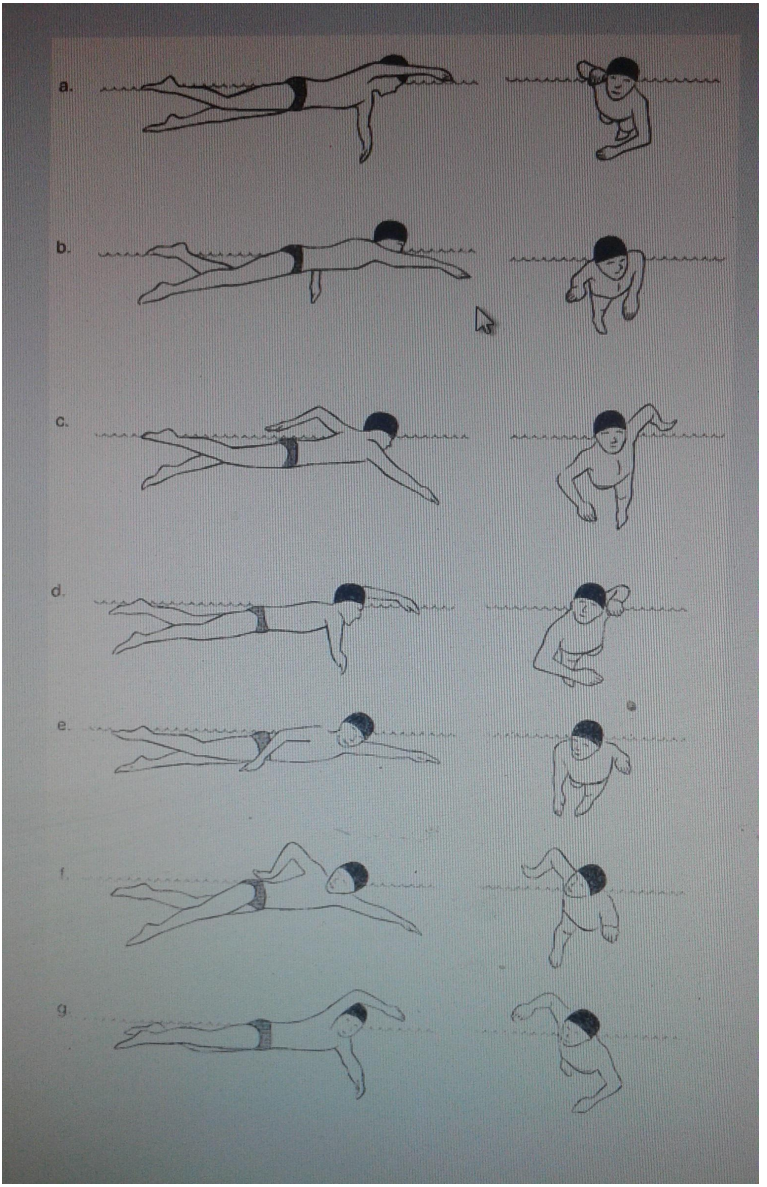
If you want to look at it another way, your body should be swimming following the sine function of a period of 0.75 seconds.



←--------Time period of 0.75 seconds----→

We can see in the following illustration that the swimmer's position is repeated every so often, this is the period or the time in which the complete stroke should be done.

In fact it is in the swimmer's vertical movement of going up and down that the SMH is produced.


a.
b.
c.
d.
e.
f.
g.

I have also tried this in the sea and the results are the same. However, going into resonance at the same time as the waves is a different story seeing as they have their own natural frequency and it is difficult for two physical oscillators to go into resonance (the waves and the natural frequency of our body).

To put it another way, the waves are a little irritating, not much, however the satisfaction of doing it in the sea is incomparable. Nonetheless, as I have said, you should not worry too much about the details as the results are almost the same.

You should measure the time period of the waves, that close to the shore is fairly constant. If their oscillation period is approximately something less than a second it would be incredibly helpful. So less than a second from when they begin to form close to the shore, where they go up and down, until they disappear.

However, if the oscillation of the waves was one second or half a second the periodic force that the waves exert would be misaligned with our own periodic force when swimming. For this reason it is usually better to do it in a swimming pool or in a totally calm sea.

In this case we should swim perpendicular to the coast to make the most of the rise and fall of the waves, although this should be something less than a second, approximately, in order to make the most of them.

We see that the same formula is used to measure the oscillation period of a pendulum and to measure the flotation period of a body that is similar to a board.

In a simple pendulum (h) is the length of the chord, in the case of your body swimming (h) is the average width of your side.

In reality the exercise is simplified a lot by breathing correctly, because our bodies use the same system as a submarine; when we surface for air the inhaled air increases our weight and makes us go down, we should then release the air so that we can rise to the surface more easily.

We should inhale very quickly to try to go down in 0.35 seconds and then quickly expel the air to return to the surface in 0.35 seconds; since the time in which we have to do the whole movement is about 0.70 seconds, with some variations depending on the volume of each person.

Lastly, the human body is not the same as a board, but an approximation of 80% is good enough. Approximations are used continuously in physics as they greatly simplify the calculations in many cases, and many times they are perfectly valid for resolving the problems that we face.

*Note: This chapter describes the job carried out by an oscillatory force that goes into resonance, it can be ignored completely if you are not interested in the detailed physics of the development of the process.

Chapter 3: Physics explanation of the system

The physical formulation of the phenomenon of resonance is formulated in the following way for free bodies where a periodic force applies.

The work formula, that is to say the energy that produces the force over our body is:

$$W = Fo * x * \cos(0)$$

If both vectors are parallel:

$$W = Fo * x$$

The power is that which results from the work in relation to the time.

Deriving from both sides we get the power on one side, and on the other side the constant comes out of the derivative, and the derivative of the movement is the velocity.

$$P = Fo * v$$

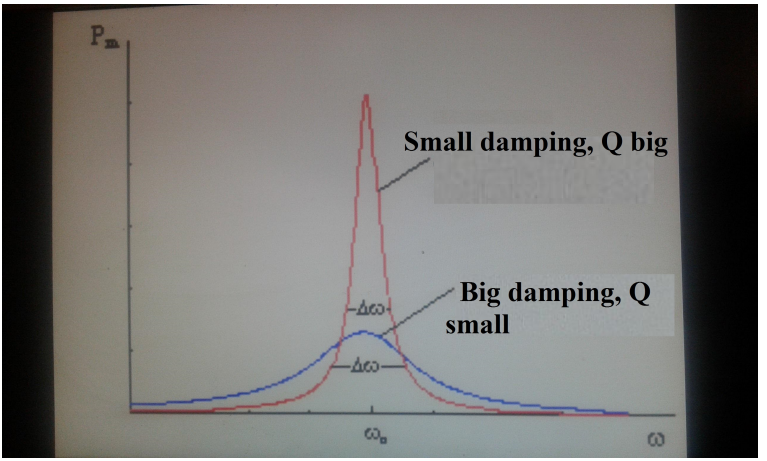
As (v) is the velocity of the oscillatory force we will give:

$$v = A * Wo*\cos (Wo*t)$$

We see that it is a function of time and that the rest are constants. This power, transmitted to the other body upon entering into resonance, makes the range of the movement of the other body grow considerably.

In a system in resonance, the range of the other oscillating body stretches to infinity. Consequently, in an instant the energy produced per unit of time is very big compared to the force that we exert.

The curves that represent the average power transmitted to an oscillating body according to the applied oscillating force are called resonance curves.



When both frequencies are similar the power increases rapidly.

The damping is a parameter that measures the intensity of the resonance.

Which in the case of our system, made up of a solid body and a mass of water, is relatively small, consequently the average power grows quickly.

In reality, the movement is governed by a second order differential equation, since the water produces a dampening effect.

The differential equation is the following:

$$mx''=-kx-bx'+Fo*\cos(wt)$$

In this equation the resistive term is indicated by the term (b) which is proportional to the velocity.

By including this term, the frequency of the resonance is produced a little earlier than in the case of forced oscillations without dampening, but in the majority of cases the frequency of resonance without dampening can be used.